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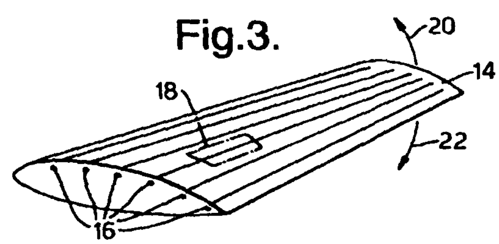
(54) Structure monitoring system using optical fibres.

(57) Apparatus and method for utilising the deformation characteristics of optical fibre transmission paths to enable the detection of deformations in materials, said fibres being so disposed in relation to the material such that each separate deformation in the material lying in the path of the fibre results in a corresponding independently measurable deformation along the length of the said fibre.

Fig.3.



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Th invention relat s to the field of crack and deformation d tection in mat rials and more specifically to th utilisation of the sp cific material properties of polymer optical transmission paths in the detection of th said deformities.

The utilisation of both glass fibre and polymer waveguides in optical methods of monitoring and detecting deformations within structural materials is well documented. To detect material failures, optical fibres are normally bonded to various locations on the surface of structures or embedded in the matrix of a composite materials such that when cracks or significant deformations occur in the said material the optical fibre's break at the position of deformation on the surface of or within the structure. By utilising optical time domain reflectometry techniques the positions of the fibre fractures can be calculated and thus the active monitoring and measurement of specific material failure characteristics is possible.

The major drawback with the current methods of crack detection utilising optical fibres is that once the test fibre has broken no further information relating to events any further along the fibre path can be recorded and subsequently the fibre must be replaced to resume analysis.

According to our invention in one aspect thereof there is provided apparatus for the detection of deformation in a material comprising at least one optical fibre defining an optical transmission path within said material, said at least one fibre being adapted for connection to an optical time domain reflectometry system, and so disposed within said material that deformation of the material results in a corresponding deformation of said optical transmission path the location of which may be determined by said optical time domain reflectometry system.

According to our invention in a further aspect thereof there is provided a method for utilising the deformation characteristics of optical fibres defining optical transmission paths to enable the detection of deformities in a material, comprising disposing said fibres within the material such that each separate deformation in the material results in a corresponding independently measurable deformation of said fibres.

The invention will now be described by way of a non limiting example in which:

Figure 1 is an illustrative sectional diagram showing a series of optical transmission fibres embedded in a material matrix;

Figure 2 is a block diagram showing an arrangement of optical test and recording equipment;

Figure 3 is an illustrative diagram showing optical fibres applied in accordance with the invention to a wing structure; and

Figure 4 is an illustrative diagram showing an enlarged area of Figure 3.

Referring to Figure 1, optical fibres 2 are embedded in a matrix 4 of a fibre r inforced composite material 5 which in turn forms part of a load bearing structure, for exampl a wing skin s ction. Optical fibres are typically in the order of 10 to 50 micrometers in diameter, but advanc s in fibre manufacture may facilitate the use of substantial smaller diameter fibres.

Referring to Figure 2 the optical fibres 2 of Figure 1 (shown as a group 12) are arranged within the matrix of a composite material 5 such that the ends of each fibre are connected to an optical splitter 10 which in turn is connected via an input fibre 8 to an optical time domain reflectrometer 6.

Figure 3 shows a typical application of the invention whereby a plurality of optical fibres 16 are embedded in the surface of an aircraft wing 14 and arranged so as to lie substantially perpendicular to the expected direction of material failures within that structure. As the wing undergoes deformation in modes typical to that identified by arrows 20 and 22 the surfaces of the wing structure will correspondingly undergo repeated compressive and tensile loadings thus increasing the probability of mechanical failures within the said wing structure.

Figure 4 shows an enlarged plan view of an area 18 on the wing of Figure 3, showing one optical fibre 24 so disposed in location to the wing structure such that under the action of structural loading in directions 20 and 22, mechanical failures or cracks occur in locations such as that shown 26 and 28. The fibre 24 possesses characteristics such that in response to these mechanical failures it's extension over areas 26 and 28 causes corresponding strain deformations or necking of the fibre in positions 30 and 32.

In use the optical time domain reflectrometer 6 sends a series of light pulses along fibre 8 which are then directed into the plurality of optical fibres 12 by the action of the optical splitter 10. If, in the wing section under analysis, there are any mechanical failures such as 26 and 28 which correspond to fibre positions along the wing there will be produced corresponding strain deformations 30 and 32 causing modifications to the timed response of the reflected light signal back from the fibre 24 through the optical splitter 10 to the optical time domain reflectrometer 6. The changes in the timed response to reflected light signals can be calibrated such that the positions of structural failures 26 and 28 in relation to the wing structure under test 14 can accurately be established in association with the magnitude of the structural deformations there present.

It will be appreciated by those skilled in the art that the apparatus and method herein described may be applied to various forms of structural testing including building construction, automotive engineering, marine engineering and associated technologies wherein there is a requirement to monitor the structural integrity of materials under load. Additionally the ptical fibres may b manufactured from a number of

materials including glass, polymers and other materials capable of facilitating optical time domain reflectometry.

Claims

1. Apparatus for the detection of deformations in material comprising at least one optical fibre defining an optical transmission path within said material, said at least one fibre being adapted for connection to an optical time domain reflectometry system, and so disposed within said material that deformation of the material results in a corresponding deformation of said optical transmission path the location of which may be determined by said optical time domain reflectometry system.

2. A method for utilising the deformation characteristics of optical fibres defining optical transmission paths to enable the detection of deformations in a material comprising disposing said optical fibres within the material such that each separate deformation in the material results in a corresponding independently measurable deformation of said fibres.

Fig.1.

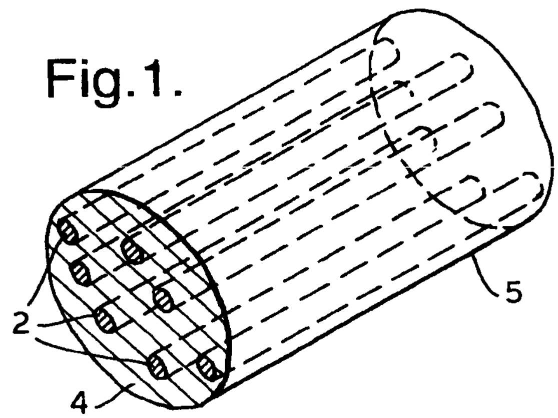

Fig.2.

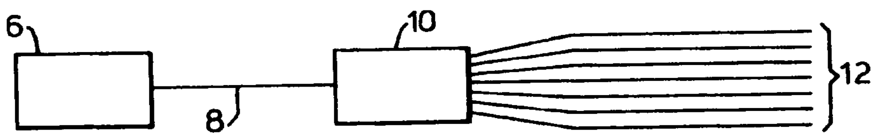

Fig.3.

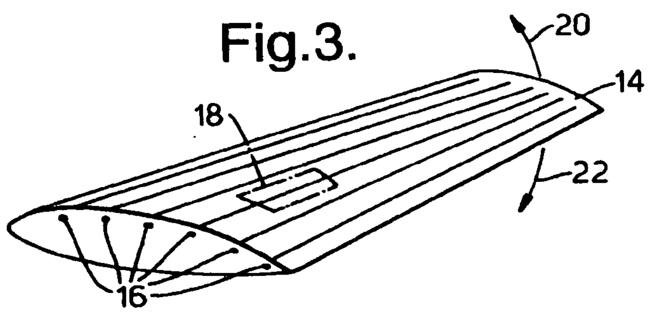

Fig.4.